CERES Programmable Azimuth for Instrument Inter-calibration and Coverage of Field Campaigns

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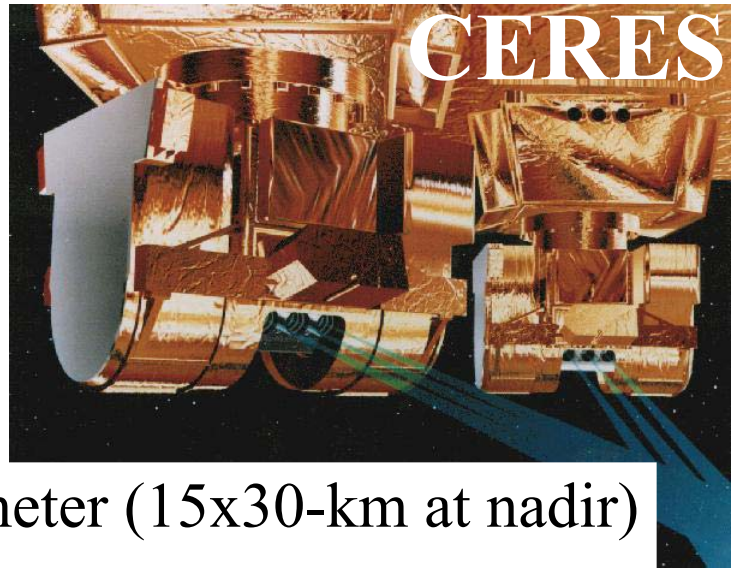
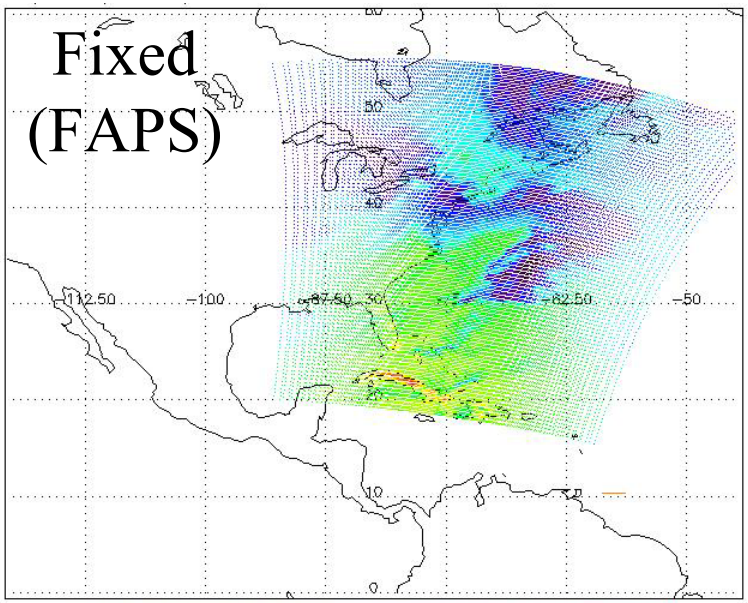
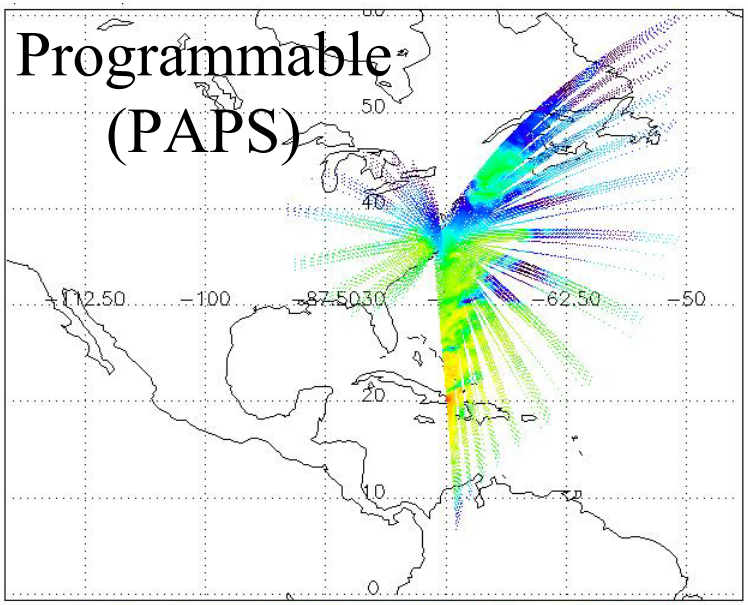
Cloud and the Earth's Radiant Energy System

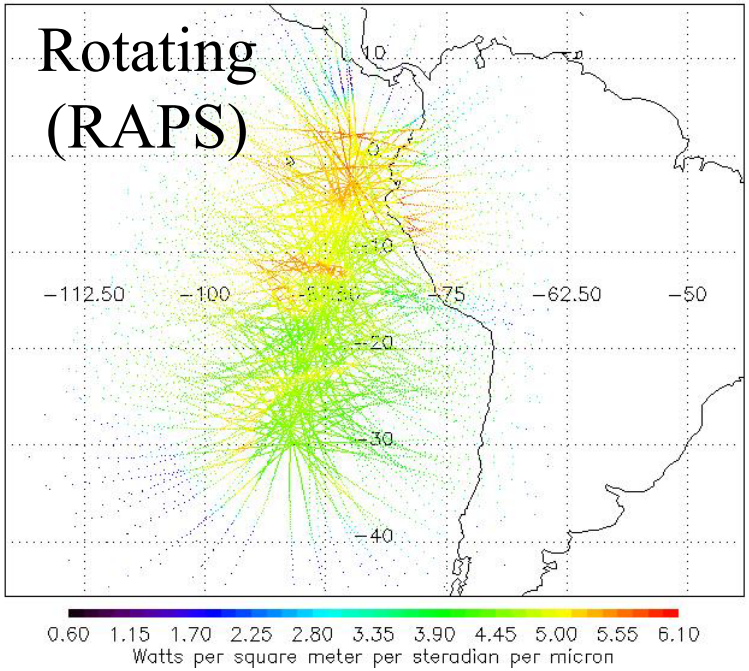


- Narrow field-of-view scanning radiometer (15x30-km at nadir)
- Measures radiances in 0.2-4μm 0.2-100μm and 8-12μm
- Calibration stability monitored with
  - On-board calibration sources (blackbodies, lamps, solar)
  - Multi-channel and multi-instrument consistency
  - Geophysical calibration
- Gain drifts can be detected at the 0.1% level
- CERES/Terra: 0.25% LW, 0.1% SW and 0.1% WW (per year)

CERES Azimuth Plane Scan Modes







PAPS for Inter-Calibration

CERES scanning plane is programmed to match the viewing geometry of other instruments:

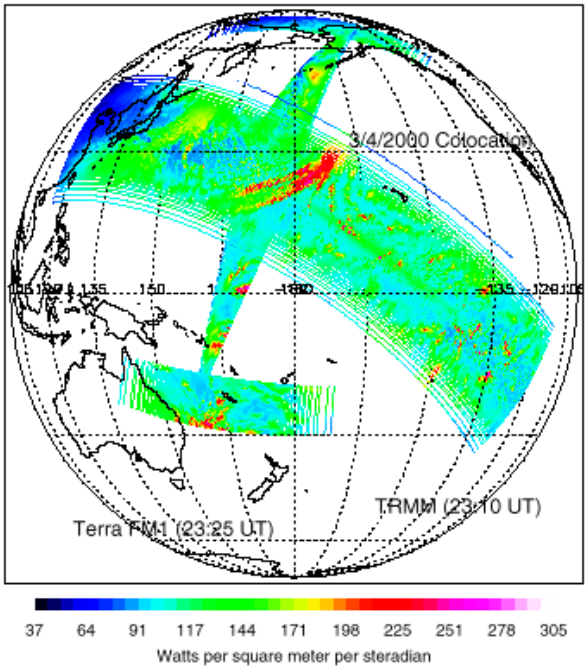
- Instrument inter-calibration
- Direct comparisons of measured radiances
- Difference due to error in gain and unfiltering process
- Comparison uncertainty dominated by spatial noise

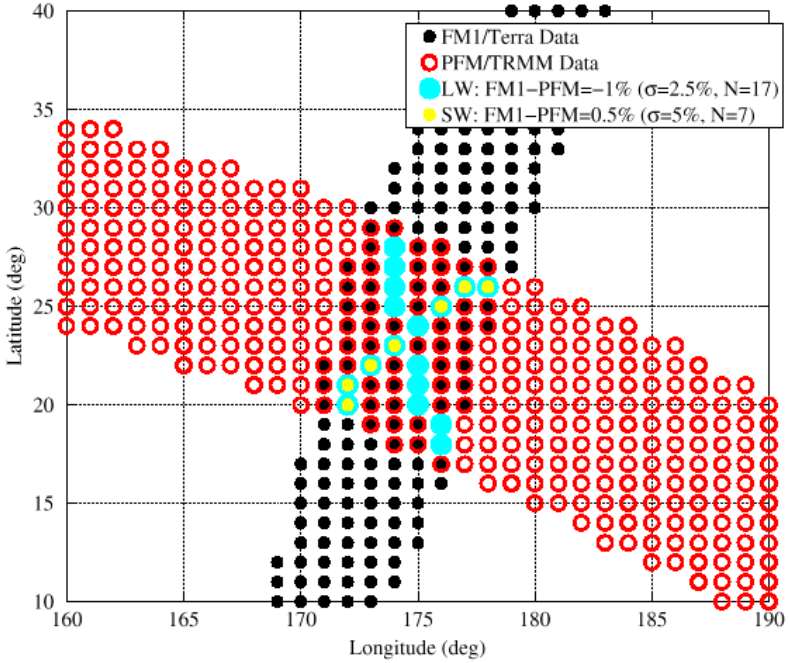
Examples:

- CERES/TRMM vs ScaRaB/Resurs
- CERES/TRMM vs CERES/Terra

LEO Satellite Inter-Calibration

- Satellite orbital periods must be different (sun-sync & precessing)
- Scan planes aligned at orbital crossing to match azimuth angle
- Collocated data with matched viewing zenith angle
- Main source of uncertainty is spatial noise





Previous LEO Satellite Inter-Comparisons

- Each orbital crossing is an independent sample
- Uncertainty $\varepsilon = \frac{t_{\alpha/2}\sigma}{\sqrt{N}}$
- Spatial noise dominates
- 100 independent samples
- σ(SW) x 4σ(LW)

($Wm^{-2}sr^{-1}$)		Δ	σ	N	ε
CERES-ScaRaB	SW	1.1	2.2	26	0.9
	LW	-0.5	0.5	50	0.2
TRMM-Terra	SW	-0.3	2.2	120	0.4
	LW	0.1	0.4	120	0.1

PAPS for Angular Model Validation

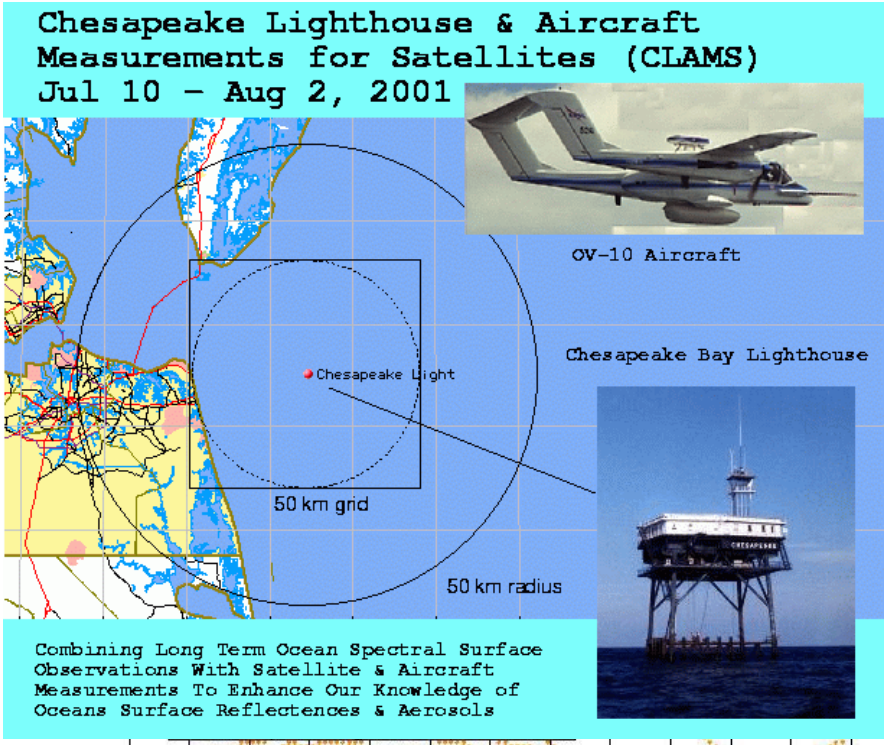
1. CERES scanning plane programmed to provide multi-angle observations of a pre-defined target:
   - Multiply spatial coverage of target area by 10
   - Reduce uncertainty of instantaneous radiant fluxes
   - Compare measured and modeled BDRF
2. Intensive observations of particular azimuth planes
   - Study anisotropy in principal plane (clear ocean)

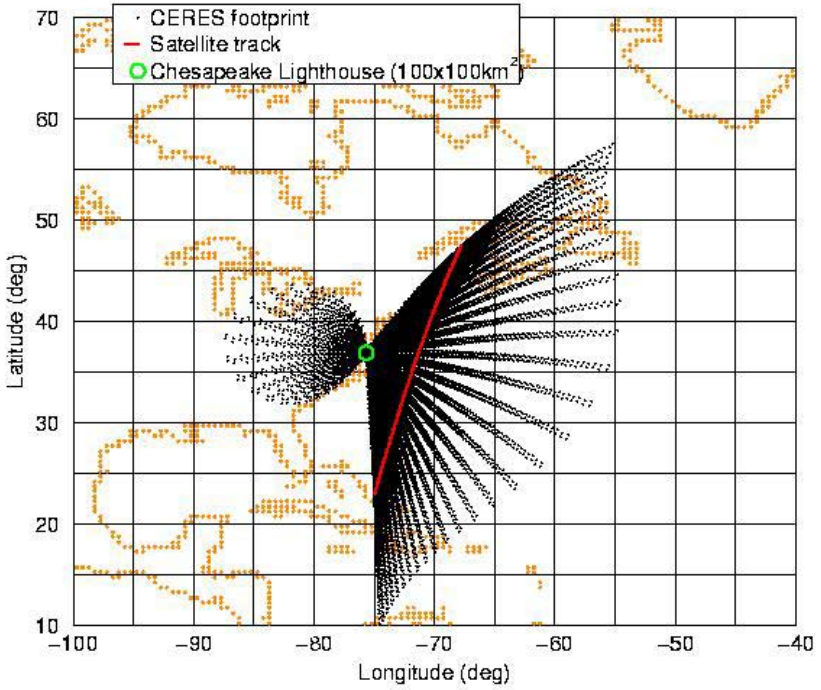
Method

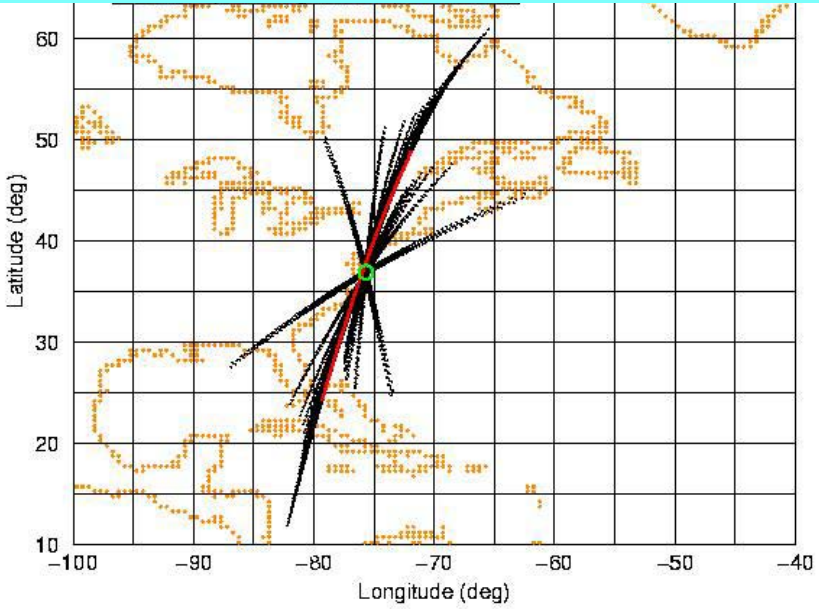
- Define target location, or azimuth plane, or viewing geometry to match
- Get orbital prediction of sub-satellite location for dates of interest
- Compute CERES azimuth angles required to provide desired viewing geometry
- Produce command file for CERES upload

CERES Operations during CLAMS

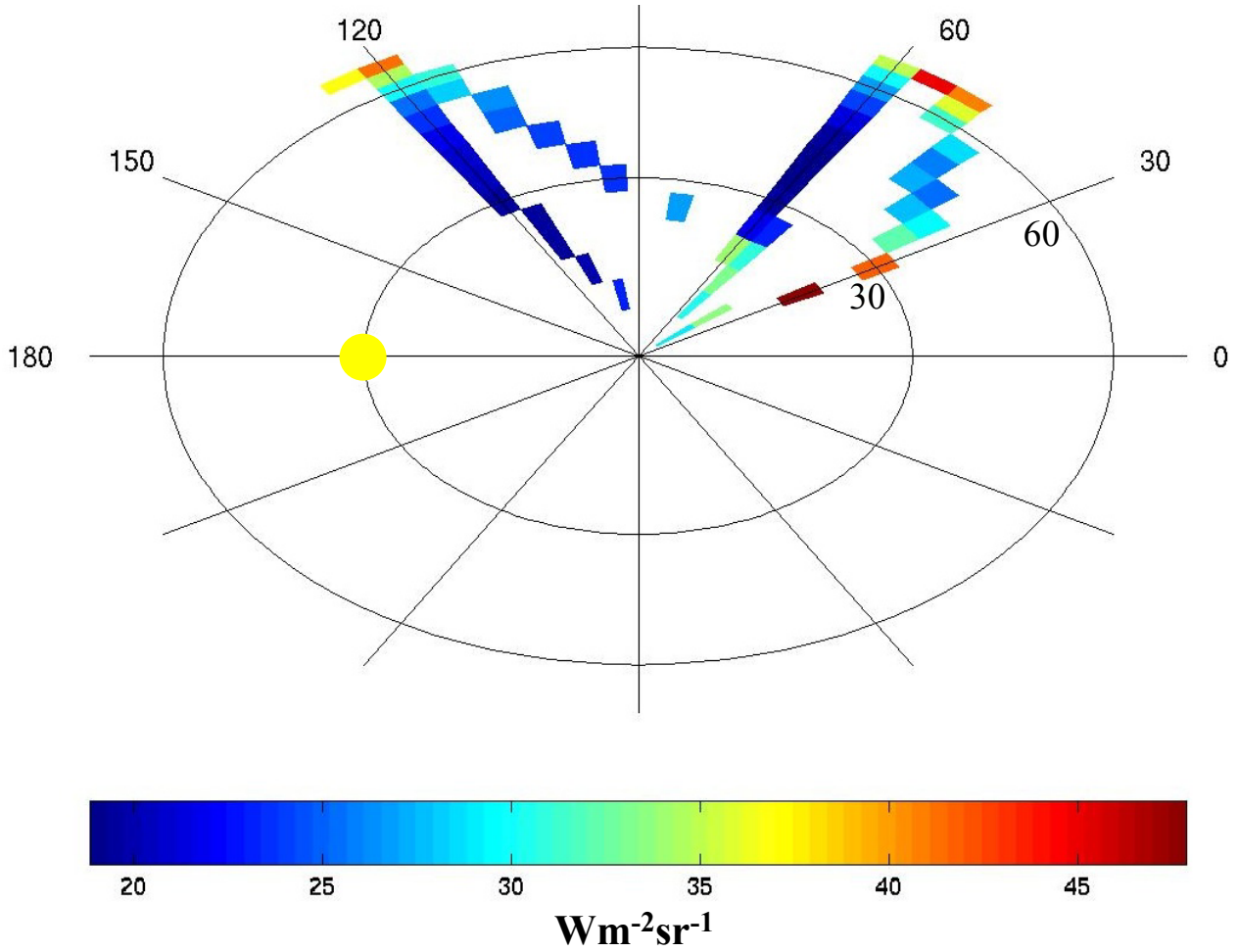
- PAPS + FAPS observations from July 10 to Aug 02, 2001
- Enhanced observation of ocean surface reflectance

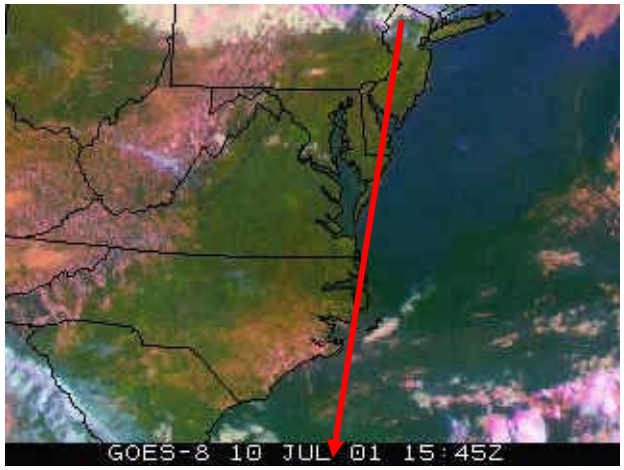


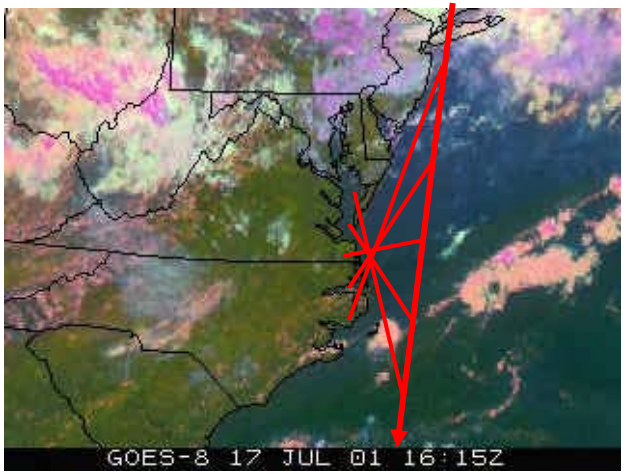




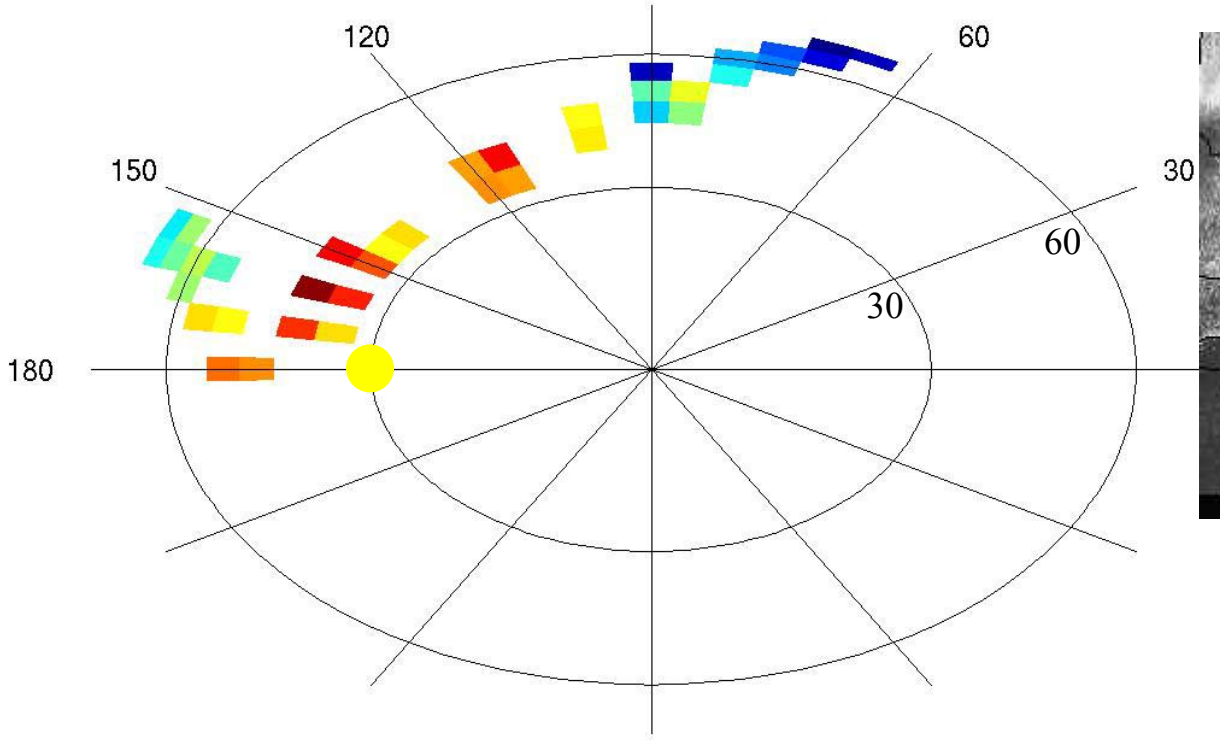
Reflected SW Radiances Clear-Sky Ocean (CLAMS July 10 + 17, 2001)

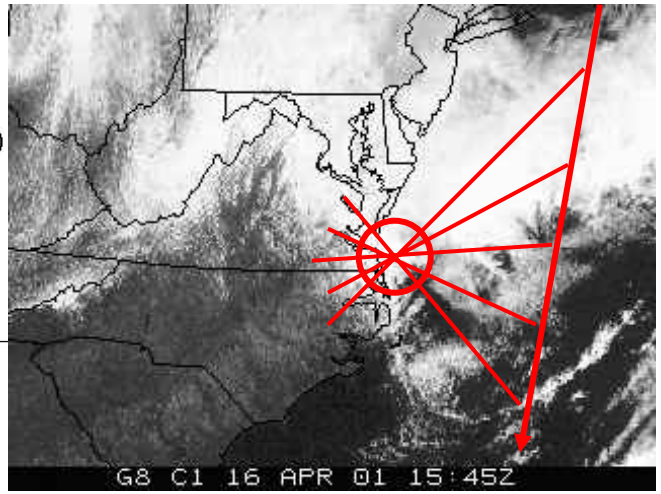


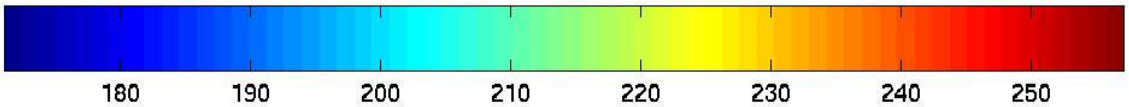




Reflected SW Radiances
Overcast Coastal Region







$Wm^{-2}sr^{-1}$

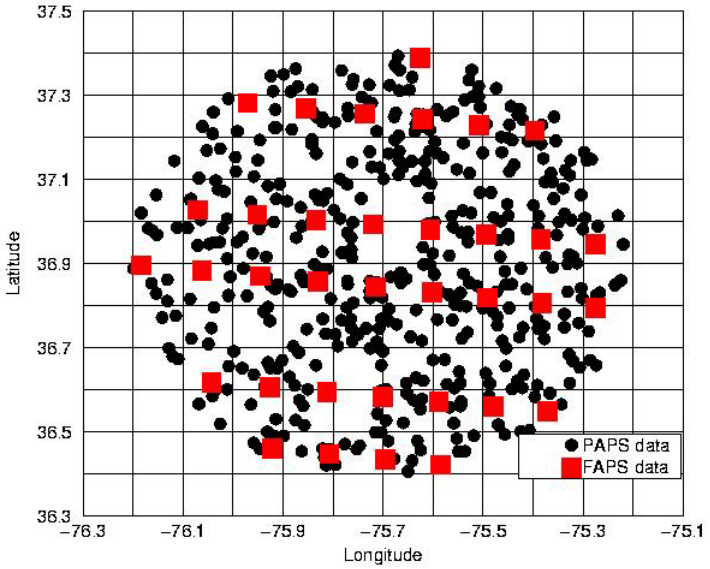
Spatial vs Angular Variability

	Flux (Wm^{-2})	σ (Wm^{-2})	D=σ/F (%)	N
FAPS	724.8	46.4	6.4	35
PAPS	676.9	54.8	8.1	447

$$D^2(Angular) = D^2(Total) - D^2(Spatial)$$

PAPS ➡ Total + FAPS ➡ Spatial

D(Angular) = 4.9%



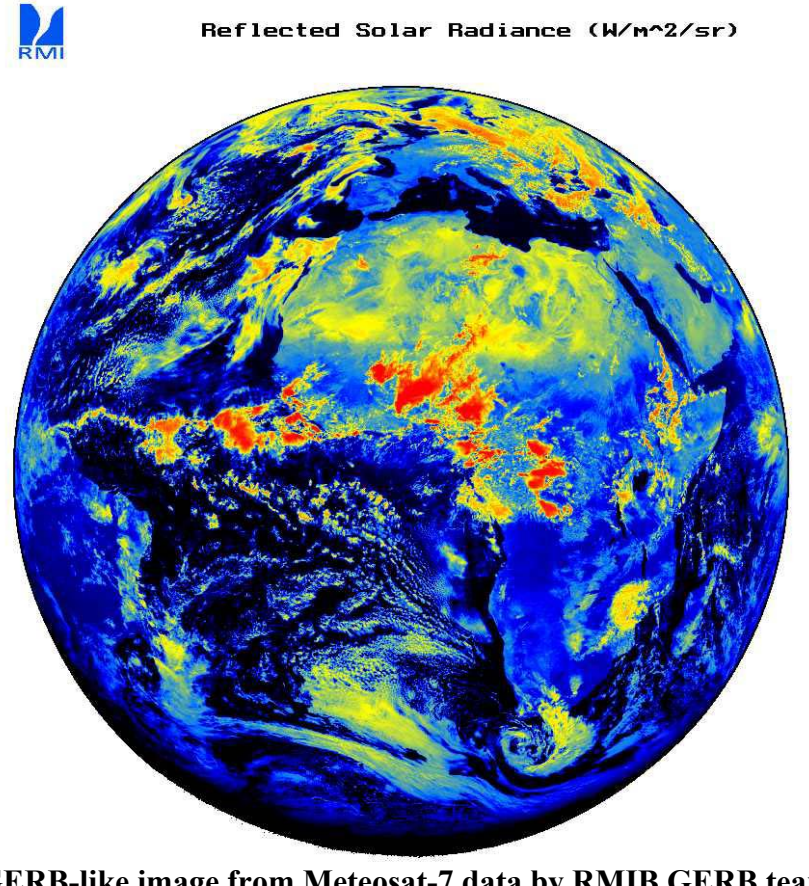
Inter-Calibration of GERB and CERES

GERB:

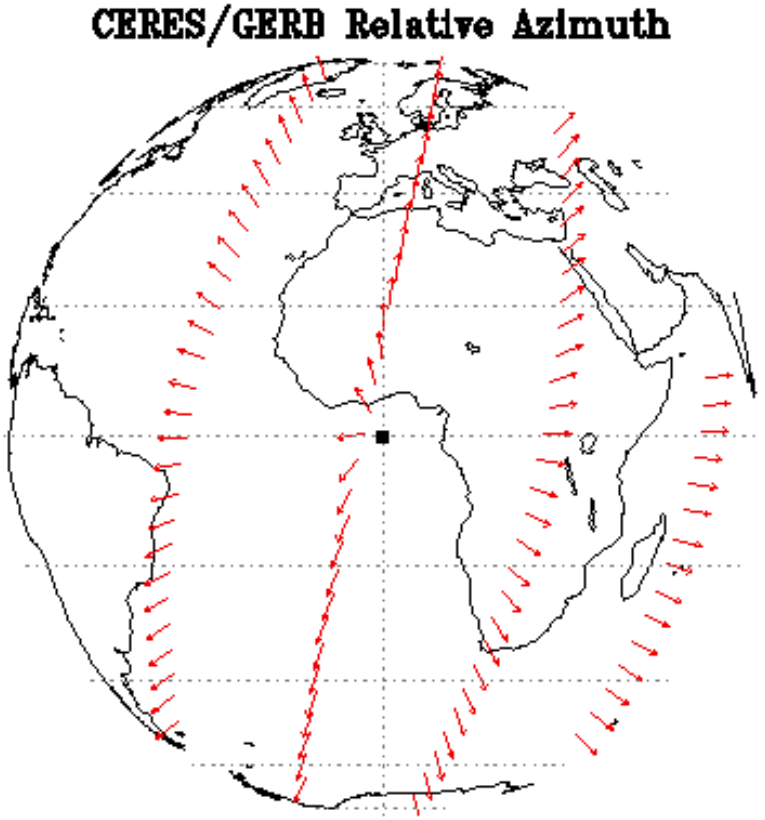
- 50-km resolution
- 256 detectors

CERES:

- 20-km at nadir
- 1 scanning detector



GERB-like image from Meteosat-7 data by RMIB GERB team



Inter-Calibration of GERB and CERES

- In RAPS mode the azimuth of CERES and GERB are matched 11% of the time (±10deg tolerance: 20/180 deg)
- In PAPS mode the azimuth of CERES and GERB are matched continuously (100%)
- Spatial noise due to FOV size differences can be reduced by averaging data over 1-deg regions
- In PAPS mode each Terra orbit provides 1 independent comparison of CERES and all GERB detectors

95% confidence interval in the comparison (using 1-deg spatial average)

(%)	Sample/ orbit	30 days		75 days	
		SW	LW	SW	LW
PAPS	120	0.5	0.1	0.3	<0.1
RAPS	13	1.5	0.3	1.0	0.2

Future CERES PAPS Activities

- Intensive sampling of particular relative azimuth planes
- Inter-calibration with GERB
- Multi-angle observation of deep convective clouds during CRYSTAL-FACE
- The CERES team welcomes suggestions for use of the enhanced spatial and angular sampling mode for specific applications

- Visit http://asd-www.larc.nasa.gov/PAPS